

CLAIMS

What is claimed is:

- 1 1. An article comprising:
2 a plurality of first heat transfer structures disposed in a matrix of a
3 second heat transfer structure;
4 a solder preform disposed on the matrix; and
5 a transition between the matrix and the solder preform, wherein the
6 transition is selected from an interface and a concentration gradient.

- 1 2. The article according to claim 1, wherein the matrix is a polymer,
2 and wherein the plurality of first heat transfer structures is selected from graphite,
3 diamond powder, inorganic dielectric particles, and metal particles.

- 1 3. The article according to claim 1, further including:
2 a middle heat transfer structure disposed between the matrix and the
3 solder preform, wherein the middle heat transfer structure includes a
4 composition that is transitional between the composition of the matrix and
5 the composition of the solder preform.

- 1 4. The article according to claim 1, further including:
2 a middle heat transfer structure disposed between the matrix and the
3 solder preform, wherein the middle heat transfer structure includes a
4 composition that is transitional between the composition of the matrix and
5 the composition of the solder preform, wherein the transition between the
6 matrix and the solder preform includes a first interface between the solder
7 preform and the middle heat transfer structure and a second interface
8 between the middle heat transfer structure and the matrix.

1 5. The article according to claim 1, further including:
2 at least one particulate material in the matrix in addition to the
3 plurality of first heat transfer structures.

1 6. The article according to claim 1, wherein the plurality of first heat
2 transfer structures includes a concentration region in a portion of the matrix.

1 7. A package comprising:
2 a heat spreader;
3 a die disposed below the heat spreader; and
4 a heat transfer composite disposed above and on the die and below
5 and on the heat spreader, wherein the heat transfer composite includes:
6 a plurality of first heat transfer structures disposed in a matrix
7 of a second heat transfer structure, wherein the matrix is a polymer,
8 and wherein the matrix is disposed on the die; and
9 a solder preform disposed on the matrix, wherein the solder
10 preform is disposed on the heat spreader.

1 8. The package according to claim 8, wherein the heat spreader includes
2 a cladding layer selected from nickel, nickel-copper, and gold.

1 9. The package according to claim 8, wherein the die includes a
2 cladding layer selected from nickel, nickel-copper, and gold.

1 10. The package according to claim 8, wherein the die includes an active
2 surface and a backside surface, the package further including:
3 a mounting substrate, and wherein the die is electrically coupled at
4 the active surface to the mounting substrate.

- 1 11. A process of forming a heat transfer composite, comprising:
2 laminating a solder preform to a matrix to form a heat transfer
3 subsystem; and
4 bonding the matrix to the solder preform, wherein the matrix is
5 formed by a process selected from:
6 co-extruding and singulating a plurality of first heat transfer
7 structures and a second heat transfer structure; and
8 mixing, casting, curing, and singulating a plurality of first
9 heat transfer structures and a second heat transfer structure.
- 1 12. The process according to claim 11, wherein the matrix includes a
2 polymer, and wherein bonding includes a process selected from cold stamping and
3 pressing under a heat load.
- 1 13. The process according to claim 11, wherein the matrix includes a
2 polymer, and wherein bonding achieves the heat transfer composite with a transition
3 between the matrix and the solder preform, wherein the transition is selected from
4 an interface and a concentration gradient.
- 1 14. The process according to claim 11, wherein bonding includes
2 supplying the solder preform material, selected from a base solder alloyed with an
3 active element material, indium, tin, tin-indium, silver, tin-silver, tin-silver-indium,
4 lead, tin-lead, lead-free solder, and combinations thereof.
- 1 15. The process according to claim 11, wherein bonding is carried out in
2 a pressure range from about 200 pounds force to about 400 pounds force.
- 1 16. A method comprising:
2 disposing a heat transfer subsystem between a die and a heat
3 spreader; and

4 bonding the heat transfer subsystem to the die and the heat spreader
5 to form a heat transfer composite from the heat transfer subsystem, wherein
6 the heat transfer composite includes:
7 a plurality of first heat transfer structures disposed in a matrix
8 of a second heat transfer structure;
9 a solder preform disposed on the matrix; and
10 a transition between the matrix and the solder preform,
11 wherein the transition is selected from an interface and a
12 concentration gradient.

1 17. The method according to claim 16, further including:
2 before disposing the heat transfer subsystem between the die and the
3 heat spreader, heating the heat spreader above ambient, wherein bonding is
4 carried out for the heat transfer subsystem at a temperature of about $(T_{TIM}-$
5 $T_{AMB})/2$, wherein T_{TIM} is the melting Centigrade temperature of the solder
6 preform, and wherein T_{AMB} is the Centigrade ambient temperature.

1 18. The method according to claim 16, wherein bonding includes
2 reflowing the plurality of first heat transfer structures against the die, wherein the
3 plurality of first heat transfer structures is selected from a base solder alloyed with
4 an active element material, indium, tin, silver, tin-silver, tin-indium, silver-indium,
5 tin-silver-indium, and combinations thereof.

1 19. The method according to claim 16, further including:
2 disposing the die on a mounting substrate to form a package.

1 20. The method according to claim 16, further including:
2 coupling the die with at least one of an input device and an output
3 device.

1 21. The method according to claim 16, further including:
2 coupling the die with a computing system included in one of a
3 computer, a wireless communicator, a hand-held device, an automobile, a
4 locomotive, an aircraft, a watercraft, and a spacecraft.

1 22. A computing system comprising:
2 a heat spreader;
3 a die disposed below the heat spreader;
4 a heat transfer composite disposed above and on the die and below
5 and on the heat spreader, wherein the heat transfer composite includes:
6 a plurality of first heat transfer structures disposed in a
7 polymer matrix of a second heat transfer structure, wherein the
8 polymer matrix is disposed on the die; and
9 a solder preform disposed on the polymer matrix, wherein the
10 solder preform is disposed on the heat spreader; and
11 at least one of an input device and an output device.

1 23. The computing system according to claim 22, wherein the computing
2 system is disposed in one of a computer, a wireless communicator, a hand-held
3 device, an automobile, a locomotive, an aircraft, a watercraft, and a spacecraft.

1 24. The computing system according to claim 22, wherein the die is
2 selected from a data storage device, a digital signal processor, a micro controller, an
3 application specific integrated circuit, and a microprocessor.